DAU “Hot Topics” Forum: DoD Human Systems Integration

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OPNAV N151

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Overview: What is HSI?

- **HSI is a multi-disciplinary strategy for the design and life-cycle support of systems**
  - Based on human-centric issues (Warfighters First!)
  - Executed as a systems engineering activity
  - Requires unique mind-set to system design
- **Main priorities:**
  - Maximize Total System Performance
  - Minimize Life Cycle Cost

Overview: What is HSI?

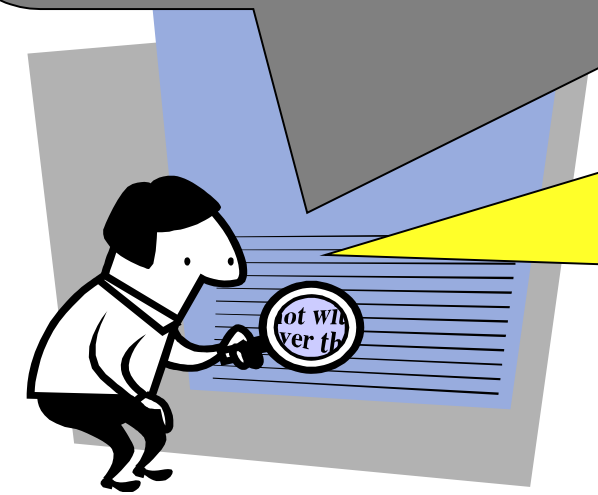
Human Factors Engineering	Manpower	Personnel	Training	Habitability	Personnel Survivability	Environment, Safety and Occupational Health
Human Performance Human Interfaces Human Error Avoidance Top Down Analysis Design for Usability Design for Maintainability	Workload Wartime Requirements (Quality/Quantity) Peacetime Requirements (Quality/Quantity) Officer, Enlisted and Civilian Force Structure Operating Strength	Personnel Classification Selection Recruiting Retention Career Progression Skill Mix Special Skills Occupational Standards Distribution Manning Concepts	Knowledge, Skills and Attitudes Initial Skill Skill Progression Functional Individual and Team Training Concepts Initial & Follow-on Delivery Systems Organic Training Embedded Training Distance Learning Virtual Environment Intelligent Tutoring	Quality of Life Quality of Work Environmental Limits and Controls Personnel Services	Anti-Fratricide Personnel Protection Damage Control Performance Effects of Ensembles	Accident Avoidance Safety Hazard Avoidance Health Hazard Avoidance Risk Mitigation Medical

TRADE-OFF ANALYSES

ENHANCE TOTAL SYSTEM PERFORMANCE WHILE REDUCING LIFE-CYCLE COST

HSI in Systems Acquisition: DoD Directive 5000.1 (12-May-03)

E1.29 Total Systems Approach. The PM shall apply human systems integration to optimize total system performance (hardware, software, and human), operational effectiveness, and suitability, survivability, safety, and affordability. PMs shall consider supportability, life cycle costs, performance, and schedule comparable in making program decisions. Planning for Operation and Support and the estimation of total ownership costs shall begin as early as possible.



E1.27 Systems Engineering. Acquisition programs shall be managed through the application of a systems engineering approach that optimizes total system performance and minimizes total ownership costs.

HSI in Systems Acquisition: DoD Instruction 5000.02 (2-DEC-08)

E8.2. “HSI planning shall be summarized in the Acquisition Strategy and SEP and shall address the following:HFE, Personnel, Habitability, Manpower, Training, SOH, & Survivability”

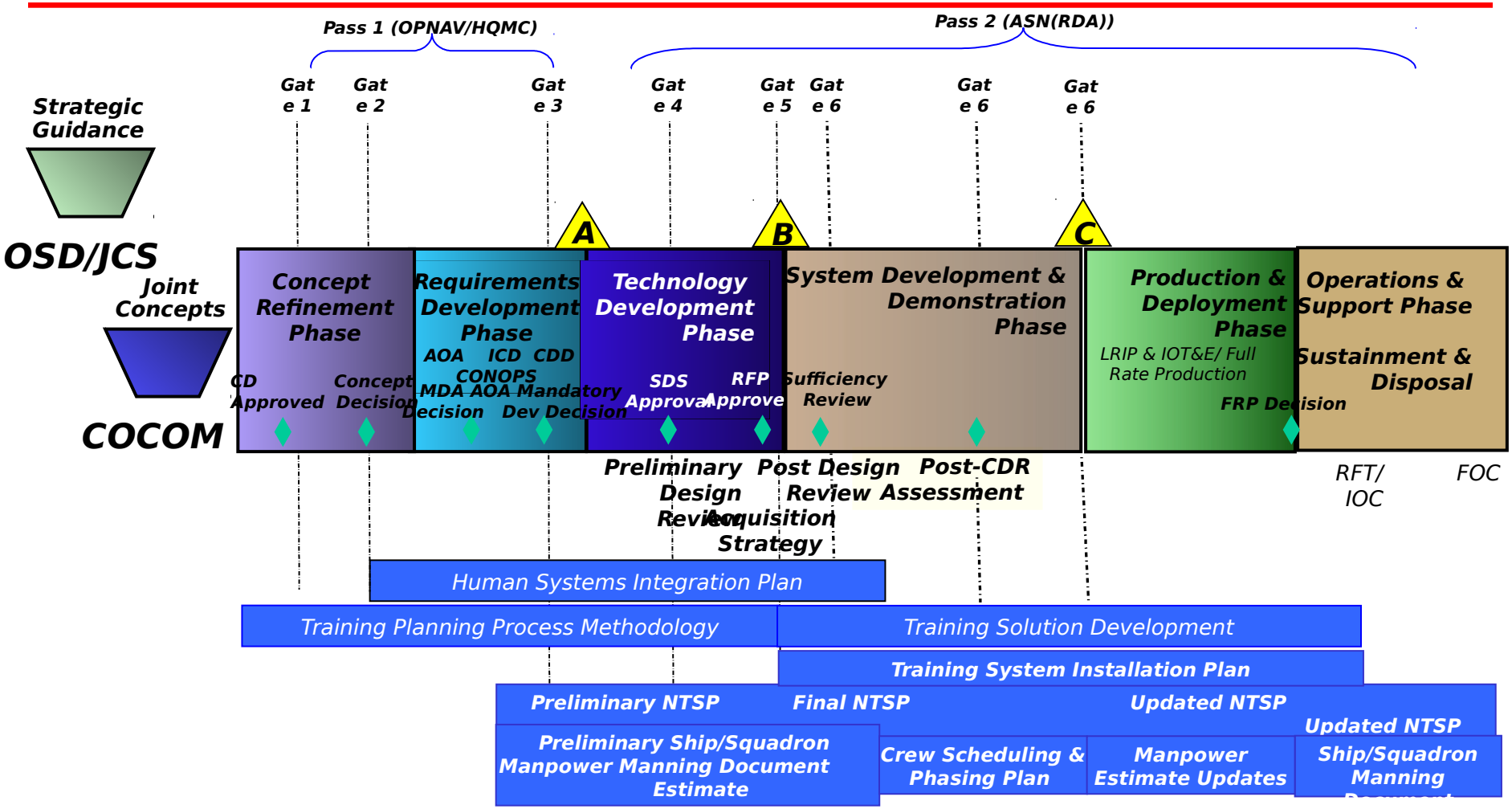
Enclosure 8

E8.1. “The PM shall have a plan for HSI in place early in the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system.”

Service HSI Related Policies

	ARMY	NAVY	AIR FORCE
Policy	•AR 70-1, Army Acquisition Policy. •DA PAM 70-3, Army Acquisition Procedures. •AR 602-2, Manpower and Personnel Integration in the System Acquisition Process (DRAFT in staffing). •AR 40-10, Health Hazard Assessment Program in Support of the Army Acquisition Process. •AR 385-10, The Army Safety Program. •AR 73-1, Army Test and Evaluation Policy.	•SECNAVINST 5000.2, Implementation of Operation of the Defense Acquisition System and the Joint Capabilities Integration and Development System. •OPNAVINST 5310.23, Navy Personnel Human Systems Integration. •OPNAVINST 1500.76B, Naval Training Systems Requirements, Acquisition, and Management. •NAVSEAINST 3900.8A, Human Factors in the Naval Sea Systems Command.	•AFPD 63-1/20-1, *Acquisition and Sustainment Life Cycle Management*, Paragraph 3.18 (3 Apr 2009). •AFI 63-101, *Acquisition and Sustainment Life Cycle Management,* Paragraph 3.79 (17 Apr 2009). •AFI 63-1201, *Life Cycle Systems Engineering*, Attachment 5 (23 Jul 2007). •AFI 10-601*, Capabilities-based Requirements Development*, Paragraph 3.3.13.12 (31 Jul 2006). •AFI 99-103, *Capabilities-Based Test and Evaluation,* Paragraph 2.5 (20 Mar 2009, Chg 2). •*AFPD 90-8, Environment, Safety, and Occupational Health, P*aragraphs 1.0, 4.3, 4.10 (1 Sep 2004).

HSI in Acquisition
Navy Perspective



- *Program Initiation is normally at Milestone B*
- *Program Initiation for Shipbuilding may be at Milestone A*

AoA – Analysis of Alternatives
CDR – Critical Design Review
FOC – Full Operational Capability
FRP – Full Rate Production
IOC – Initial Operational Capability
IOT&E – Interoperability Test & Evaluation
LRIP – Low-rate Initial Production
PDR – Preliminary Design Review
TDS – Technology Design Specification
NTSP - Naval Training System Plan

HSI Program Impacts

Program	Service	ACAT	Impact
Air Warrior – Long Bow Apache	Army	I	Resolved over 250 HSI related issues based on field surveys. $24M in cost savings from reduced wartime and peacetime maintenance hours. HSI investment < $100K.
Future Combat System – Mobile Combat System	Army	I	Determined optimal number of FCS mobile combat system (MCS) crew and best allocation of tasks using task network modeling. FCS ORD revised MCS crew from 2 to 3 (Threshold). Results were also transitioned to AMSAA's Analysis of Alternatives (AoA); reduced crew members from 4 to 3 on M1 Tank.
Littoral Combat Ship	Navy	I	Manpower KPP >100 ship's crew; modular design w/aviation detachment.
AEGIS Combat Information Center (CIC)	Navy	I	Combat team of 4 doing the previous work of 8; No increase in overall workload.
F-16 Block 40/50 Glass Cockpit Multinational Staged Improvement Program (MSIP)	Air Force	I	One Year design simulation was funded for $500K and is estimated to have saved a major block software change at a cost savings of $35M.
C-17 Cargo Aircraft	Air Force	I	Crew Systems, human factors, manpower, personnel, and training efforts credited with saving 2,916 Manpower positions over the predecessor system. Life Cycle Cost Savings Estimated in excess of $300M. Exceptional joint aircraft with order of magnitude improvements for combat support.

HSI Success Stories: AMOD CIC Mockups

Partial DDG CIC Mockup

- **$20K Materials saved millions in costly redesign**
- **Both DDG / CG layouts evaluated**
- **Several targeted HSI evals over 9 month period (Sep 08- May 09)**
- **Evals were HSI criteria driven**
- **31 Significant Findings**
- **Documented Impact areas:**
  - Cost avoidance
  - Safety
  - Human Performance Enhancements
    - Situation Awareness
    - Mission Performance

- **Partial and full scale mockups used to validate**
  - Layout / egress
  - Operator Visibility
  - Maintainer access
  - Safety
- **Usability Assessments (UAs)**
  - Realistic scenarios

Full Scale DDG CIC Mockup

AMOD UA's have provided an unprecedented level of insight into the relationship of ship designs and the associated impact on human performance in the new CIC

HSI Success Stories: DDG 1000 Bridge Mockups

DDG 1000 SMC Mockup

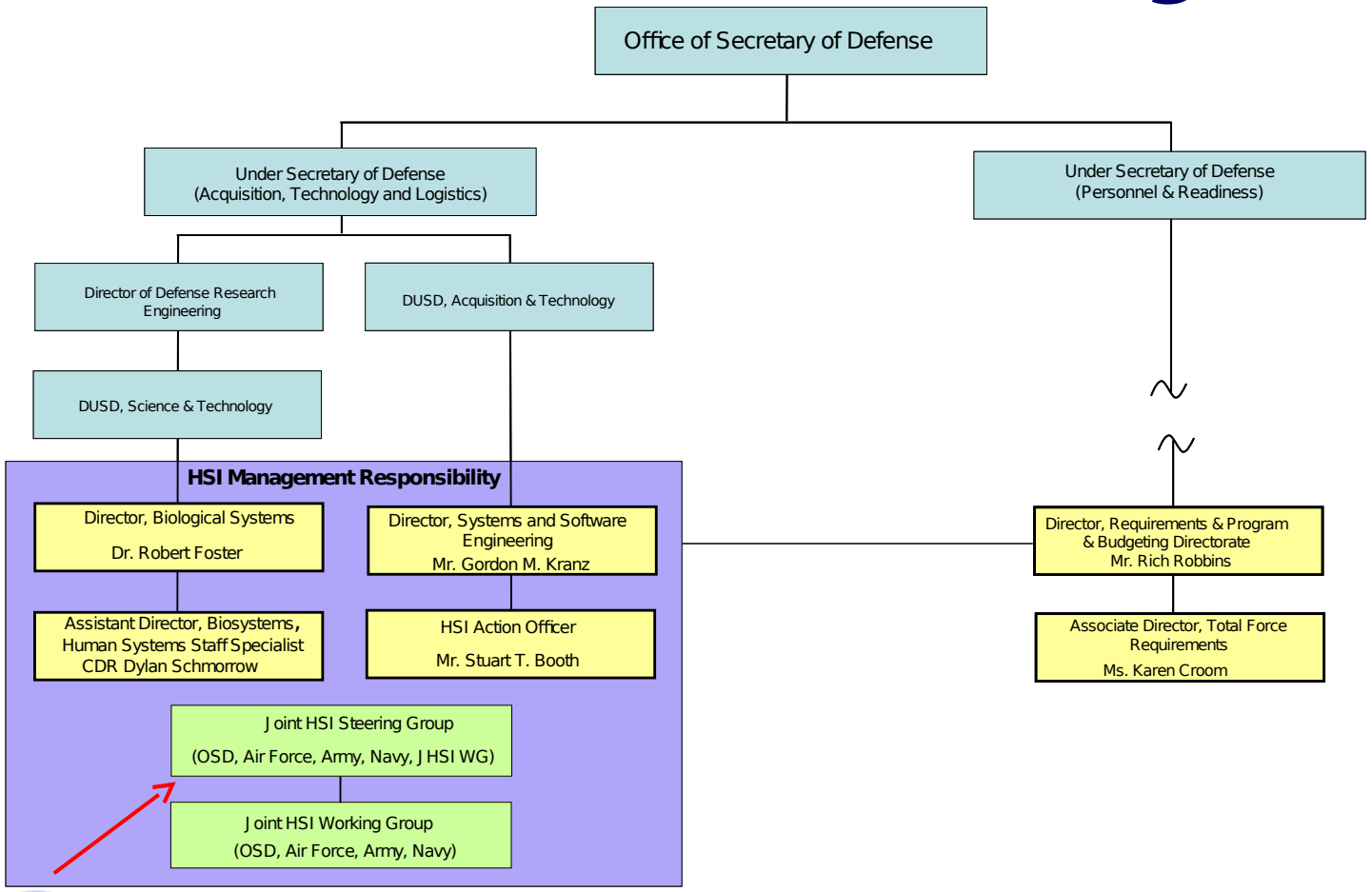
Pre-MS B

- **Full scale bridge mockup used to validate**
  - Earlier 3D CAD Modeling fly-throughs
  - Layout / egress
  - Watchstander Visibility
  - Maintainer access
  - Safety
- **Concept of Operations Exercises (COOPEXs)**
  - Realistic scenarios
    - Harbor Transit
    - Formation Steaming
    - UNREP
  - Representative Users
    - Qualified Active Duty Bridge Officers
  - Data Collection Efforts
    - Display location
    - Display content
    - Accessibility
    - Internal & external communications
    - Work flow
    - Seating Requirements

- **$20K Materials (low fidelity) saved millions in costly redesign**
- **LSDs mounted behind bridge windows used to depict ship's motion & external objects**
- **19 Significant Findings (5 Structural Changes)**
- **Documented Impact areas:**
  - Cost avoidance > $22 M
  - Human Performance Enhancements
    - Safety Risk Mitigation
    - Mission Performance
    - Third Bridge W/S Validated

The ROI has been realized by reduced technical & schedule risk, reduced acquisition costs, and cost avoidance of rework if evaluations had been conducted at IOC.

OSD HSI Management Organization


Office of Secretary of Defense
Under Secretary of Defense (Acquisition, Technology and Logistics)
Under Secretary of Defense (Personnel & Readiness)
Director of Defense Research Engineering
DUSD, Acquisition & Technology
DUSD, Science & Technology
HSI Management Responsibility
Director, Biological Systems
Dr. Robert Foster
Director, Systems and Software Engineering
Mr. Gordon M. Kranz
Director, Requirements & Program & Budgeting Directorate
Mr. Rich Robbins
Assistant Director, Biosystems, Human Systems Staff Specialist
CDR Dylan Schmorrow
HSI Action Officer
Mr. Stuart T. Booth
Associate Director, Total Force Requirements
Ms. Karen Croom
Joint HSI Steering Group
(OSD, Air Force, Army, Navy, J HSI WG)
Joint HSI Working Group
(OSD, Air Force, Army, Navy)
We're Here

Joint HSI Working Group
Proposed Sub-Groups

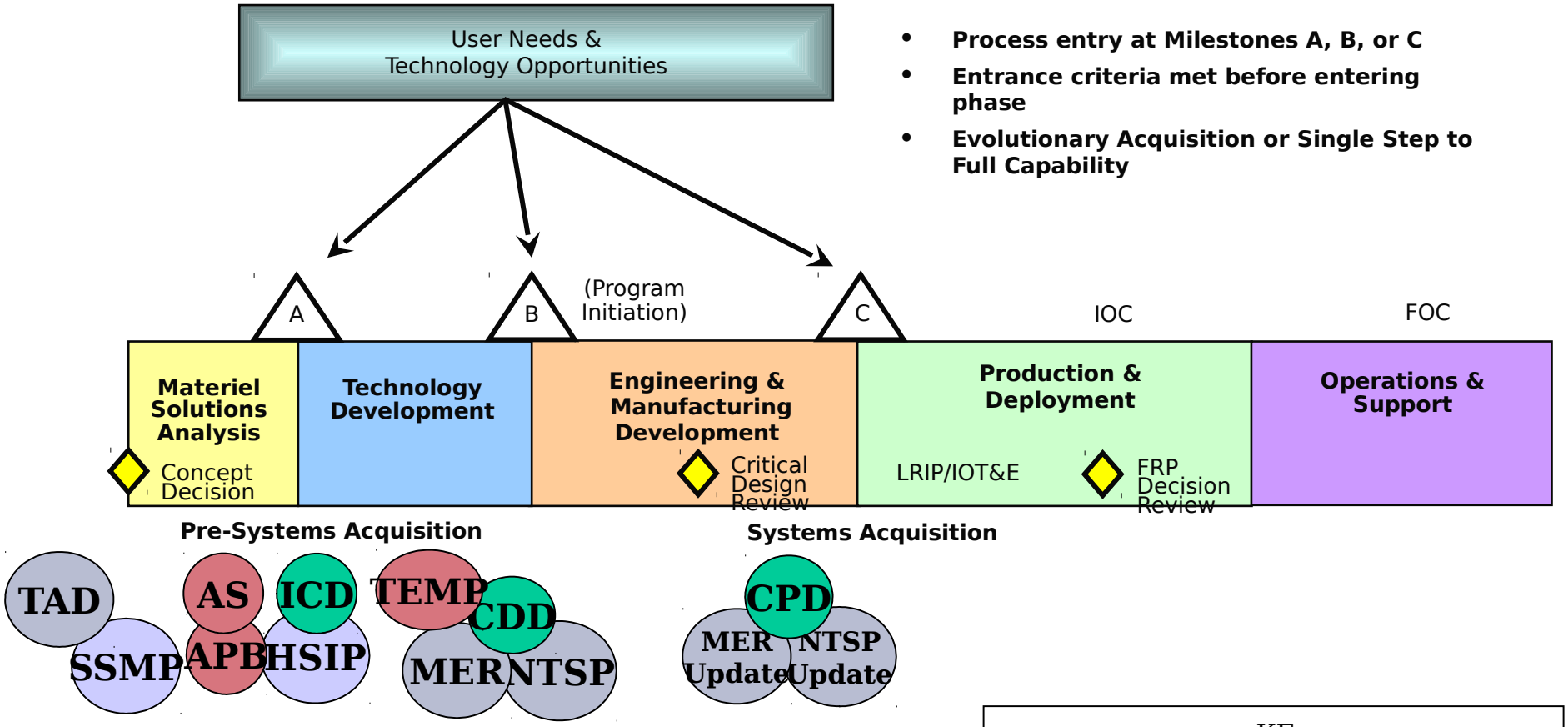
- ***Questions?***

BACK-UP

HSI Deliverables

Service	Deliverable
Navy	▪IAW ONI 1000.16K, a Human Systems Integration Plan (HSIP) is required prior to MS B. However, SNI 5000.2D only requires HSI planning be conducted. Note: N151 submitted language to the revised SNI 5000.2D (SNI 5000.2E) that requires the MDA or PM to determine the need for an HSIP. ▪Currently, there is no HSI deliverable required by DoD or SECNAV policy. However, NTSPs and MERs are considered HSI artifacts by the ASN RD&A and SYSCOMs. ▪Moving forward, ONI 5310.23 lays the fundamental groundwork for HSI requirements in JCIDS; thus implicitly establishing the need for HSI planning to be conducted.
Army	▪The Army requires MANPRINT Assessments (HSI Assessments) for all programs. ▪HRED consolidates HSI domains assessments into DRAFT MANPRINT Assessment for submission to G-1 MANPRINT office. ▪G-1 MANPRINT analysts evaluate the assessment and provide Director with concurrence/non-concurrence recommendation. ▪Army programs require G-1 MANPRINT approval.
Air Force	▪Due to organizational alignment, the AF is currently determining the deliverables, in addition to HSI requirements and resources.
Coast Guard	▪Do not have an HSI plan deliverable. ▪Coordinate with PM to develop Manpower Requirements Determination Estimate, and closely monitor contractual language for MPTE requirements.

HSI in Systems Acquisition: Related Program Documentation



- **Process entry at Milestones A, B, or C**
- **Entrance criteria met before entering phase**
- **Evolutionary Acquisition or Single Step to Full Capability**

KEY

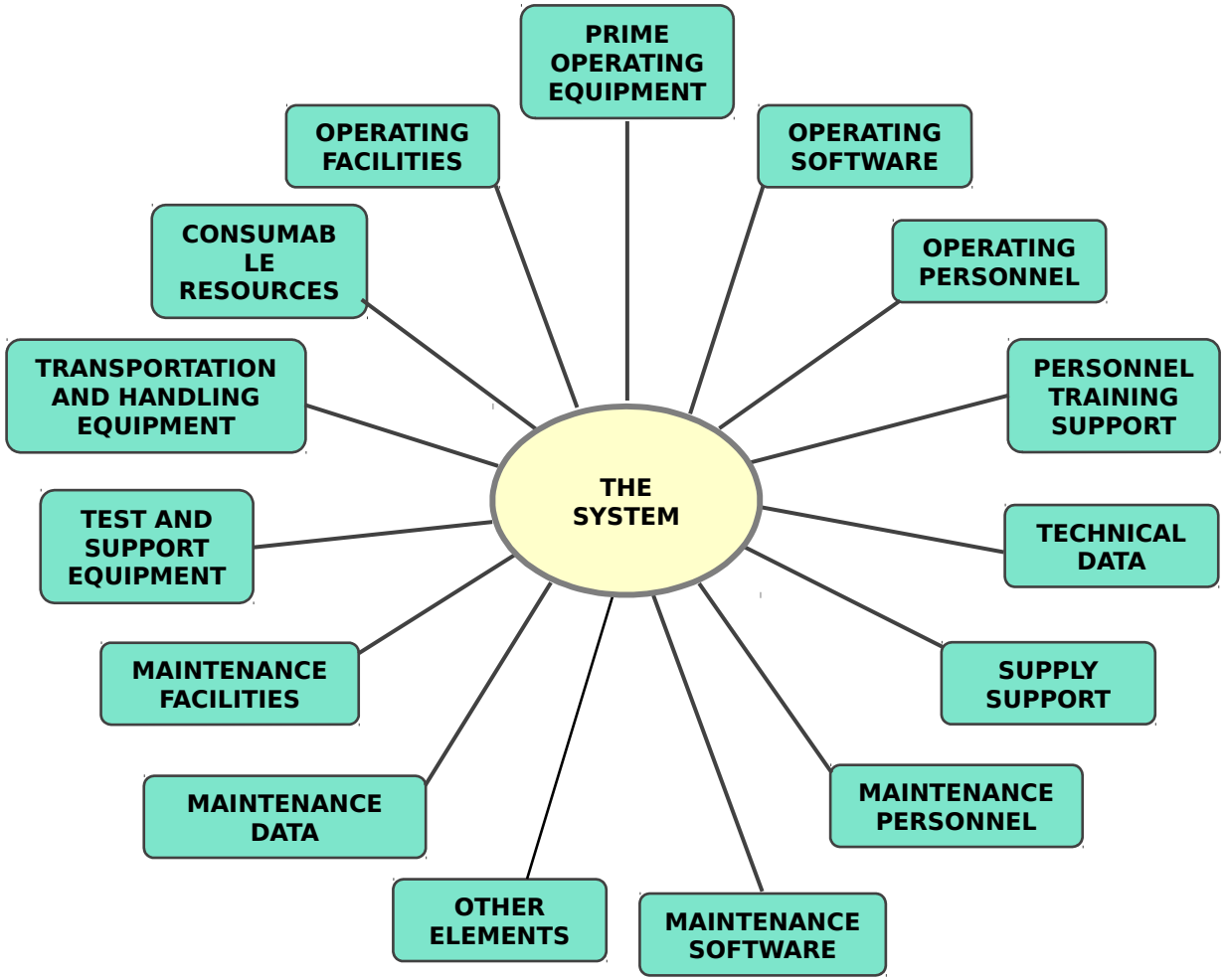
- Requirements / Required (CJCSI/M 3170.01C)
- Program Management / Required (DoD 5000)
- HSI / Required (Title 10, DoD 5000, SECNAV 5000.2C)
- HSI / Recommended

HSI is System Design: System Elements

- ***Warfighting systems are complex***

  Design must consider technical capabilities and operational realities

  Operations, maintenance, & support are equally important



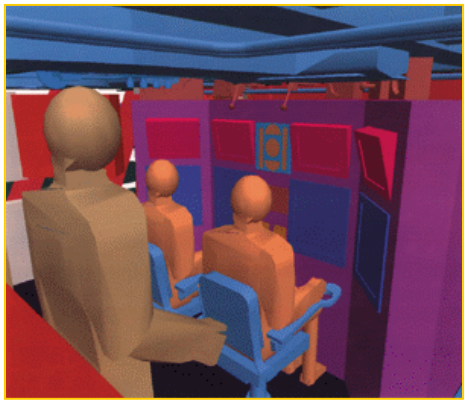
HSI Success Stories: Virginia Class Submarine

SSN 774 Design Concept

Pre-MS B

- **Ergo Man avatars used in 3D CAD environment for real-time human performance assessments across multiple design configurations**
- **Full scale mock ups of CACC to support Concept of Operations Exercises (COOPEX) evaluated:**
  - Layout / egress
  - Operator visibility / reach
  - Safety
  - Team Comms
  - Situation Awareness

- **Millions saved in Life Cycle Cost**
- **Photonics system allowed enhanced W/S team configuration in CACC**
- **Documented Impact areas:**
  - Life Cycle Cost avoidance
  - Safety
  - Human Performance Enhancements
  - Manpower / Workload Reduction (reduction of 7 crew members compared with SSN 688I)



3D CAD View of CACC

The ROI has been realized by reduced technical & schedule risk, reduced acquisition costs, and cost avoidance of rework if evaluations had been conducted at IOC

HSI Success Stories: CREW 3.1

- **Counter Radio-Controlled IED Electronic Warfare (CREW) 3.1 is Manpack Variant Jammer**
- **Response to JUONS (no HSI rqts. in place)**
- **HSI Organized in Logistics**
- **JCREW is follow-on ACAT program**

An example of a wearable CREW system.

HSI is a rqt for JCREW

Dismounted CREW device strives to meet JCREW HSI requirements.

- **3 HSI Heuristic Evaluations**
- **Significant HSI Findings:**
  - Harness Straps Interfere w/ Battle Gear esp. in prone
  - Battery Interferes w/ Battle Gear esp. in prone
  - Antenna Breakage Unacceptable
- **Design Changes**
  - Harness Design Improved
  - Battery Relocated to back
  - Antenna Ruggedized

CREW HSI Evals resulted in early design changes and an increase to antenna reliability, reducing TOC.

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HSI Success Stories: LCS 1 Hearing Protection

- **Entire crew has custom molded hearing protection**
  - Solid plug
  - Sleep plug
  - Communications plug
- **3D CAD model, "Designer Noise", developed under SBIR N98-094, predicted the ship board noise aboard a high-speed ship such as LCS 1.**

USS Freedom (LCS 1) Underway

LCS 1 Custom Molded Earplug Suite

- **Custom molded earplugs provide a consistent fit for each wearer, increasing hearing protection effectiveness.**
- **6 month follow up revealed >95 % crew retained pre-deployment hearing levels**
- **Prototype for flight deck cranial custom molded earplugs on USS EISENHOWER**
- Documented Impact Areas: **Safety, hearing loss/tinnitus disability cost avoidance, Human Performance enhancement (communications).**

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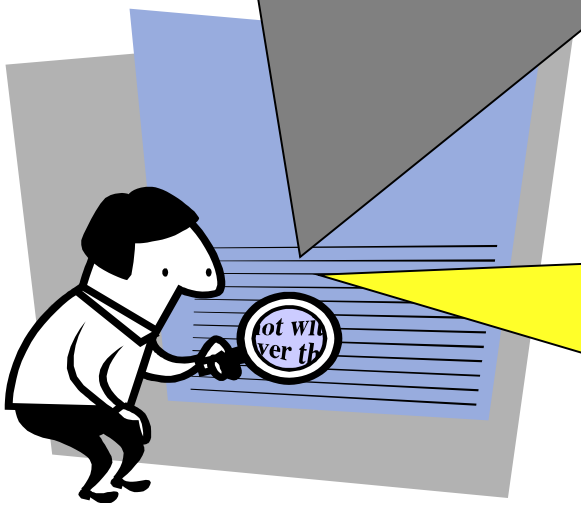
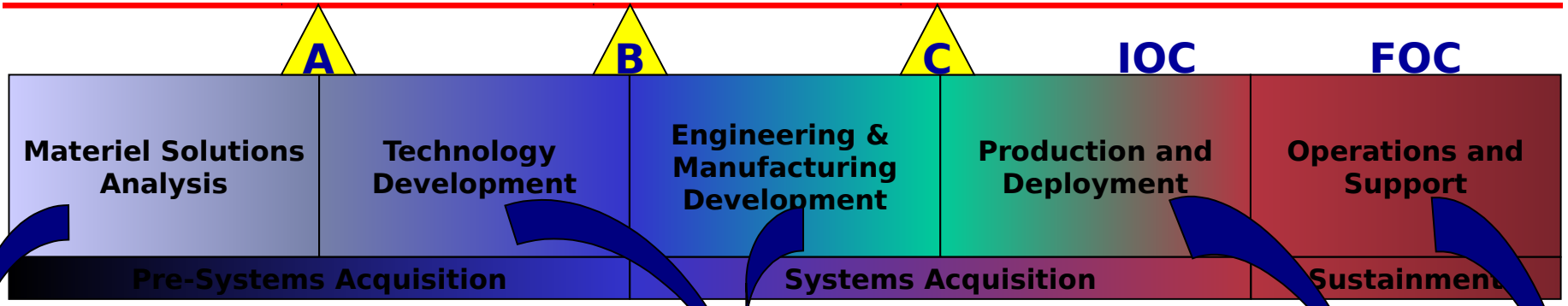
HSI in Systems Acquisition: SECNAV 5000.2D *(16-Oct-2008)*

The PM shall apply HSI as part of a systems engineering approach. HSI is that aspect of systems engineering and PM's efforts that addresses the extent to which humans will be required to operate, maintain, and support the resultant design, including analysis to reduce manpower, improve human performance, improve system reliability and usability, and minimize personnel risk.



7.2.1 <u>HSI in Acquisition</u>. PMs and sponsors shall address HSI throughout all phases of the acquisition process to optimize total system performance, minimize total ownership costs, …

HSI in Systems Acquisition



Mission Decomposition
Functional Decompositions
Top Down Functional Analyses
Alternative Manning Strategies
User-Centered Concepts of Operation
Training Concepts of Operation
Display and Control Guidelines
Display and Control Reference Model
HSI Performance Metrics
HSI Requirements

Requirements Reviews
HSI Plan Review/Acceptance
Quantitative Requirements
Performance Metrics
HSI Documentation
HSI Design Review/Certification
Usability Test Plans/Testing
Test Plan Reviews

HSI Software Development
HSI Software Validation
HSI Software Verification
Testing
Training System/Documentation Review
Maintainability Validation

Concept Refinement Evolution
Task Analyses
Functional Allocation
Manning Analyses
Workload Analyses
Team and Individual Reqts
Personnel Skill Reqts
Training Reqts Analysis
Training System Reqmts

HSI Test Bed
Display Prototyping
User Interface Hardware Controls
Human Performance Modeling
Experimental Design
Technology Demonstrations

EC Concept Paper
CPCR Review
ECP Review

Requirements Elicitation
Fleet Feedback Analysis
MPT Effectiveness

HSI in Systems Acquisition

New Systems Acquisition

- "Clean-Sheet-of-Paper" approach
  - Zero manning until justified
  - Top Down Requirements Analysis (TDRA)
  - Human Centered Design (HCD)
- ID HSI requirements for each phase
- Evolutionary acquisition; spiral development

Modernization of Legacy Systems

- Add HSI to upgrades, consider future benefits
- Derive HSI Issues from:
  - Lessons learned from predecessor system
  - Evolving CONOPS and doctrine
  - Impact of new capabilities

HSI in Acquisition Scenarios

Prototype to Production Acquisition

- Performance Specs should track incremental improvements on:
  - Reducing cognitive workload while enhancing decision-making abilities
  - Improving Human-machine interfaces
  - Increasing sustained performance ability
  - Preventing or minimizing human error
- Major approaches: task network and human-in-the-loop simulation

COTS/NDI Acquisition

- Provide input to ensure the developer is responsive to needs but aware of:
  - Technical and logistic risks
  - Affordability constraints
- Provide input into requirements for NDI concepts and issues
- Provide input to TOC determinations